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EDITORIAL NOTES.

THE senior Editor, Dr. Henry Woodward, F.R.S., who founded the GEOLOGICAL MAGAZINE in 1864, completed his 88th year on November 24, 1920, and is still enjoying good health and taking a warm interest in the Magazine. He played an active part in the preparation of the present issue, No. 678, the concluding number of the 57th volume.

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WE learn that the following promotions have been made in the Geological Survey: Mr. J. Allen Howe and Dr. Walcot Gibson to be Assistants to the Director, the former in London and the latter in Edinburgh; Mr. Henry Dewey and Mr. Bernard Smith to be District Geologists. We hope to give at an early date further particulars as to future developments of the work of the Survey.

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MR. C. P. CHATWIN, F.R.M.S., who so ably filled the office of Librarian at the Geological Society, Burlington House, and was made Demonstrator in Geology at the University of Liverpool in 1919, under Professor P. G. H. Boswell, has, we learn, just been appointed Assistant Palæontologist to the Geological Survey at the Jermyn Street Museum under Dr. F. L. Kitchin, M.A., F.G.S.

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ABOUT three hundred Upper Tertiary and Recent Gasteropods—labelled by the donor in illustration of his monograph published by the Palæontographical Society on the "Pliocene Mollusca of Great Britain" (vol. i)—have been presented to the Geological Department of the British Museum (Natural History) by F. W. Harmer, Esq., M.A., F.G.S.

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BY the death of Dr. Allen Sturge, M.V.O., March 27, 1919, the Department of British Mediaeval Antiquities in the British Museum, Bloomsbury, received the finest private collection of stone implements in existence. When packed, the collection, including the exhibition and storage cases that formed part of the bequest, weighed about 25 tons, and was conveyed by road from Icklingham Hall, Suffolk, to London during the summer.

The north-west angle of Suffolk is abundantly represented by specimens excavated from clay and gravel or more frequently

picked up on the surface, to a large extent by Dr. and Mrs. Sturge; and the series from Warren Hill, High Lodge, and Elveden are of the highest importance. Hundreds of Drift implements come from gravel pits in the Thames valley near Dawley (Hayes, Middlesex), and quantities from other well-known sites, such as Swanscombe, Farnham, Dunbridge, Southampton, Savernake Forest, Bedford, and Broom. A large quantity had been acquired from Mr. Worthington Smith, mostly found in north-east London; and other collections made by Canon Greenwell and Messrs Greenhill, Allen Brown, Simeon Fenton, Robert Elliot, and Thomas Bateman were incorporated.

The foreign section is also very rich, the entire contents of many French caves having been obtained from M. Reverdi. Chief among such specimens is a Solutré blade from the hoard found at Volgu in the Dépt.-Saône-et-Loire; and the French Drift and Neolithic series are well selected. Scandinavia, Western and Southern Europe are adequately represented, and there is a large collection from the Swiss lake-dwellings. An ample Egyptian series contains some of the best flint work known, and there are hundreds of excellent examples from America, South and East Africa, and Madras.[1]

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We have received a copy of the first number of a new periodical, *The Mining Electrical Engineer*, which is to be the official journal of the Association of Mining Electrical Engineers; this body has now had a useful existence of eleven years, and it has naturally felt the need of a definite organ of opinion, to place before the world a record of the work done by the Association, and to collect information as to the general progress of electrical engineering as applied to mines. The contents of this number are naturally mainly of a technical nature, and there is not very much bearing on geological questions. Nevertheless, the connexion between mining and geology is so close that we welcome this addition to the literature of the subject. The general get-up of the journal, which is profusely illustrated, is excellent, and we wish it a successful career.

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At last the Geological Society of London (following the earlier example of the Geologists' Association) have resolved to expend a sum of £500 from the invested funds of the Society to provide the means necessary to carry on scientific publications, and a special general meeting will be held on December 1, 1920, at 5.15 p.m., in order to obtain sanction to carry out this object. Having regard to the great increase in the cost of printing and paper since the War, no Fellow of the Society can doubt the wisdom of this recommendation of the Council. In addition to the

[1] A summary description in French of the whole collection was printed for the meeting of the International Congress of Anthropology and Prehistoric Archæology which met at Monaco in 1906.

above proposed provision of funds, Fellows are reminded that, after the completion of vol. lxxvi (1920), they will not be entitled to receive the Quarterly Journal regularly unless a subscription at the rate of 10*s.* per volume is paid in advance, along with their annual contribution to the Society. Those Fellows who do not require the complete series can obtain separate parts at the price of 3*s.* each, if applied for within one year of the date of issue.

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We have been informed that a proposition is on foot—between the Trustees of the British Museum and the Treasury—to revise the present scale of salaries for assistants now entering the British Museum so as to render them more in accordance with those in other branches of the public service and remove the difficulty which at present prevents many able men, with University training, from offering themselves as candidates for vacancies now actually existing in the staff of the Natural History Branch. We trust that, in addition to a *larger initial salary* about to be offered to *new men* who may apply for these vacant posts, the salaries of those older men now upon the staff will *also be increased* so as to render them more in in accordance with the changed circumstances of living in 1920–1, from which *all persons* with *fixed pre-War incomes* are suffering mostly without hope of relief.

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The ninety-seventh annual report of the Whitby Literary and Philosophical Society contains, among other matter of local interest, an excellent article by Mr. J. T. Sewell, entitled "Notes on the Geology of Whitby Sands". The rapid erosion of the boulder-clay cliffs west of Whitby is known to many, and even the writer of the present note, in the course of a not very long life, has witnessed some remarkable changes. But the variations that have taken place on the beach are perhaps of equal interest, and much more difficult to detect. Mr. Sewell has made minute and detailed observations on the spot for thirty years, recording any exposure of rock due to temporary removal of the sand and gravel by tides, waves, and currents, especially during storms, and he has thus accumulated an unrivalled acquaintance with the details of this particular stretch of foreshore. Some useful information was also acquired during the building of the pier extensions. The results are presented in a couple of large-scale maps, 12 inches to the mile, which show, among other things, that both piers rest on Lias shale. It is also very interesting to find that Mr. Sewell's observations lead him, with apparently good grounds, to doubt the existence of any fault in Whitby Harbour. This paper is an excellent example of the way in which the long-continued and careful observations of a geologist living on the spot may serve to correct the hasty generalizations of those not possessing the local knowledge so necessary in work of this sort.

ORIGINAL ARTICLES.

Sedgwick Museum Notes: Notes on the Genus *Sphaerocoryphe*.

By W. B. R. King, M.A., F.G.S.

(PLATE XIII.)

Dr. F. R. COWPER REED, in a paper entitled "Notes on the Affinities of the Genera of the Cheiruridæ",[1] points out that *Sphærocoryphe* belongs to the Cheiruridæ, while *Staurocephalus*, which has at first sight some superficial likeness to it, belongs probably to the Encrinuridæ.

Some additional light has been thrown on to this subject by the recent discovery of a complete specimen of *Sphærocoryphe* in the Ashgillian beds of Norber Brow, Austwick, near Settle, by Mr. T. H. Thorneycroft, of Pembroke College, Cambridge. Mr. Thorneycroft has kindly presented the specimen to the Sedgwick Museum. The specimen, which is referable to *Sphærocoryphe thomsoni* Reed, although somewhat compressed and crushed laterally by the cleavage, possesses all the characteristics of the species, but the chief point of interest is that the hypostome is preserved in place, and was found inside the swollen frontal part of the glabella. The hypostome and material filling the glabella broke away and remained on the "cast" side of the specimen. This appears to be the first hypostome definitely referable to a specimen of this genus. The hypostome of *Staurocephalus* is also rare, but one is figured by Salter,[2] and this is preserved in the British Museum.

Novák[3] has shown that hypostomes are of considerable use in determining the family relationship of various genera, and his contention seems to hold good in this case also. It may be as well, therefore, to describe the hypostome of *Sphærocoryphe thomsoni* which Mr. Thorneycroft found associated with the complete individual and compare it with that of other Cheirurids and *Staurocephalus*.

The hypostome is slightly smaller than the swollen frontal part of the glabella, since it was found pushed into it without contortion. The general outline is square, formed of a large central, raised, elliptical portion, surrounded by a deep wide groove and raised narrow margin. The anterior margin is not well preserved in this specimen, but appears to be slightly curved in outline and to

[1] Geol. Mag., 1898, pp. 206–14.

[2] "British Trilobites": Palæont. Soc., 1864–83, pl. vii, fig. 17.

[3] Ottomar Novák, "Studien an Hypostomen böhmischer Trilobiten": Kön. Böhm. Gesellschaft der Wissenschaften, Prag, 1879–86.

rise sharply from the groove which separates it from the central raised portion. At the lateral extremity of the frontal ridge the groove reaches the margin of the hypostome, thus forming a break in the raised marginal ring. This also makes two notches in the general square outline. The lateral margins are raised and thickened, particularly just below the notch mentioned, above and at the posterior angles. The angle between the lateral and posterior parts of the margin is sharp and about 90 degrees. The central part of the posterior border is bent slightly towards the centre of the hypostome. There are indications of a small pit in the groove opposite the posterior edge of the notch in the position shown in the restoration. The surface of the hypostome is finely granulated, as shown by its "cast".

From the restoration it will be seen that the hypostome is similar in type to the typical Cheirurid hypostome, such as that of *Cheirurus bimucronatus* Murch.[1] or Barrande's figures of Cheirurid hypostomes in his *Système Silurien*,[2] but the hypostome which shows more points in common than any other is that of *Deiphon forbesii* Barr.[3] In *Deiphon* there is the same central spherical raised portion separated by the marked groove from the raised marginal ring. The general outline is almost exactly the same in each case. In *Deiphon* the granulations on the central portion are more marked (*vide* Salter's figure) than in *Spharocoryphe*, but this may well be a result of the development of one from the other. Dr. Cowper Reed [4] has shown that the various characteristics of *Deiphon* appear to be developed from the rather less specialized form which is found in *Spharocoryphe* and the discovery of the hypostome, which has been shown to be of great use in deciding family relationships, certainly bears out his views.

Turning now to the hypostome of *Staurocephalus*, an examination of the specimen in the British Museum figured by Salter [5] shows several points which are not brought out very clearly in the figure. Firstly the specimen has suffered considerably during the development to which it has been subjected. The result is that the posterior part has been broken away to a great extent. The two knobs about the centre of the hypostome are clearly shown in the figure, but on the right-hand side, looking at the hypostome, there is clear evidence that once the anterior part of the hypostome extended laterally in the form of a wing. Just behind this wing there is a slight ledge, which may be a fragment of a border on a lower level. If this really be the case then the hypostome of *Staurocephalus* would consist of a flattish margin with marked wings and a sharply

[1] Salter, "British Trilobites": Palæont. Soc., pl. vi, fig. 11.

[2] Barrande, *Système Silurien*, vol. i, pls. xli–xlii.

[3] Salter, "British Trilobites": Palæont. Soc., pl. vii, fig. 10; and Lindström, "Forteckning på Gotlands Siluriska Crustacéer opersigt. af k. Vetenskaps-Akademiens Förhandlinger," 1885, No. 6, p. 37, and pl. xv, fig. 18.

[4] F. R. C. Reed, Geol. Mag., 1898, p. 211.

[5] Salter, op. cit., pl. vii, fig. 17.

rising blunt triangular raised central portion possessing two marked knobs, rather below the centre. The anterior part is nearly flat, with only slight undulations. The general outline of the whole would be triangular.

It is difficult to find any family with a similar type of hypostome; certain it is that it is far from the Cheirurid type, but it must also be admitted that very little resemblance can be seen between it and the normal Encrinurid type, with its peculiar and striking central tongue-like anterior protrusion.

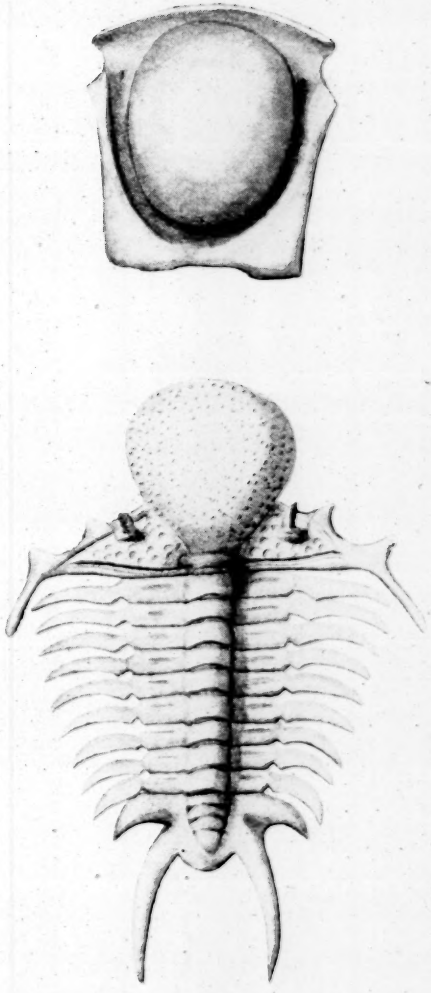
A study of the hypostome of *Staurocephalus* therefore confirms the view that it should be removed from the Cheiruridæ, but does not seem to indicate that it should be put into the Encrinuridæ unless it branched off from some very early form before the characteristic frontal tongue was developed. However, all figures of *Encrinurus* or *Cyclele* which show the hypostome have this tongue well developed. If, however, *Staurocephalus* is barred from both the Cheiruridæ and Encrinuridæ it is difficult to find a family in which to place it.

It may not be out of place here to study some points in connexion with the general structure of *Spharocoryphe* and forms of similar general appearance. As the specimen from Norber Brow, although much compressed laterally, shows all the details of the ornamentation clearly, it was decided to draw a restoration, taking the details largely from the Norber Brow specimen, but the general outline from some of the Girvan specimens, especially from a nearly complete specimen in the British Museum (No. I. 16047).

The restoration (Plate XIII) is intended to bring out some of the more striking features of *Spharocoryphe thomsoni* Reed. A detailed description of the species is given by Dr. Reed in his Girvan Trilobites monograph.[1] To this there is nothing to add, but a point which occurs to a worker on Lower Palæozoic Trilobites, is that when identifying specimens of this species it should be borne in mind that the usual type of pygidium is that shown in the restoration,[2] with apparently one short and one long spine on each side of the axis.

From the foregoing notes there would seem to be little real similarity between *Spharocoryphe* and *Staurocephalus*; the only cause of the confusion which arose between these two genera was the marked swelling of the frontal part of the glabella. This swelling is present in several other genera, particularly *Deiphon*, probably a direct descendant of *Spharocoryphe*, and also in the peculiar Australian genus *Onycopyge* described by Dr. H. Woodward.[3] Even some species of *Phacops* (s.s.), for instance *P. cephalotes* Corda from Étage G. of Bohemia, show considerable swelling of the frontal parts of the glabella. The origin and use of this peculiar line of development seems to be rather obscure, but the subject is touched upon by Dr. L. Dollo[4] in regard to *Deiphon*, where he attributes the extremely modified form to external influences connected with its mode of life.

N.B.—For footnotes see p. 538.



Reconstruction of Sphærocoryphe thomsoni Reed.

[To face p. 534.

North American Species of the Brachiopod *Etheridgina.*

By D. K. Greger, Fulton, Missouri.

(PLATE XIV.)

THE series of minute, adherent species of Brachiopoda brought together in the following discussion are usually assigned by American palæontologists to the genus *Strophalosia*, but recent writers have come to recognize the fact that, in America at least, the genus *Strophalosia* is a polyphyletic group. Dr. Stuart Weller, in his monograph on the Mississippian Brachiopoda (1914), all but recognizes the generic value of these minute shells when he points out the lack of harmony in the series of forms which he places in the genus *Strophalosia*.

Of the five American species here grouped under Oehlert's excellent genus *Etheridgina*, the *Strophalosia scintilla* of Beecher bears the closest resemblance to the genotype, *Productus complectens* Etheridge. *S. scintilla* is abundant in the fauna of the Louisiana Limestone (Kinderhookian) of Eastern Missouri, and my collection contains over three hundred examples in various stages of development—from minute spats 0·4 mm. in diameter to mature shells, the average size of which seldom exceeds 2·5 mm.

Recently, through the kindness of a Scottish correspondent, eight well-preserved specimens of *Etheridgina complectens* (Etheridge), from Fife, were placed in my hands for study and illustration, and an examination of this material brings out the following facts—the presence of a cardinal area, a covered delthyrium, attachment of the pedicle valve by cementation over the greater part of the visceral area, instead of at the beak as in the true Strophalosias, and that the clasping propensity of the spines is more apparent than real.

While fully appreciating the necessity of correct application of a generic term, our study of these minute forms leads to the conclusion that it better serves the purpose of classification to group under the genus *Etheridgina* the following so-called Strophalosias from American strata.

Genus ETHERIDGINA Oehlert.

1877. *Etheridgina*, subgenus of *Productus*. Genotype *E. complectens*. In Fischer, Manuel de Conchyliologie, p. 1278.

Etheridgina complectens (Etheridge). (Pl. XIV, Figs. 1–3.)

1876. *Productus complectens* R. Etheridge, jun., Quart. Journ. Geol. Soc., vol. xxxii, p. 462.
1878. *P. complectens* R. Etheridge, jun., op. cit., vol. xxxiv, p. 498.

From the published figures of this species I have reproduced two of the figures of Mr. Etheridge, Fig. No. 1 from his paper of 1876 and Fig. No. 2 from the 1878 paper, since they best illustrate the characters of the species as it is generally found. I have also

selected for illustration, from the Fife specimens in hand, an example attached to a fragment of gastropod shell, since this specimen shows both valves, in their natural position, and other features in an excellent manner.

ETHERIDGINA RADICANS (Winchell). (Pl. XIV, Figs. 4–8.)

1866. *Crania radicans* Winchell, Geol. Rept. Lower Peninsula of Michigan, Appendix, p. 92.
1890. *Strophalosia radicans* Beecher, Amer. Journ. Sci., vol. xl, p. 240, pl. ix, figs. 14–17.
1892. *S. radicans* Hall & Clarke, Palæont. New York, vol. viii, pt. i, pl. xv*b*, figs. 27–30.

I have seen but three imperfectly preserved examples of this species, from the limestones of the Hamilton (Devonian) from the vicinity of Alpena, Michigan. Their condition is such that specific characters are almost obliterated. Beecher and Hall & Clarke have, however, given ample illustration of the characters of the species, and figures of these authors are here reproduced.

ETHERIDGINA KEOKUK (Beecher). (Pl. XIV, Figs. 9–11.)

1890. *Strophalosia keokuk* Beecher, Amer. Journ. Sci., vol. xl, pp. 244–5, pl. ix, figs. 18–24.
1892. *S. keokuk* Hall & Clarke, Palæont. New York, vol. viii, pt. i, pl. xvii*a*, figs. 5–7.
1914. *S. keokuk* Weller, Mississippian Brachiopoda, Monogr. No. 1, Illinois Geol. Surv., p. 145, pl. xviii, figs. 17–18.

This species is fairly abundant in the Crawfordsville Shale (Mississippian) of Indiana, most frequently found attached to *Platyceras* and corals, also occasionally found on the columns of crinoids, which are abundant in the shale. I have reproduced the original figures of Beecher and one by Hall & Clarke.

ETHERIDGINA SCINTILLA (Beecher). (Pl. XIV, Figs. 12–14.)

1890. *Strophalosia scintilla* Beecher, Amer. Journ. Sci., vol. xl, pp. 243–4, pl. ix, figs. 10–13.
1892. *S. scintilla* Hall & Clarke, Palæont. New York, vol. viii, pt. i, pl. xv*b*, figs. 32–4.
1908. *S. scintilla* Rowley, Missouri Bureau of Geol., vol. viii, 2nd ser., p. 76, pl. xvii, figs. 26–9.
1914. *S. scintilla* Weller, Mississippian Brachiopoda, Monogr. No. 1, Illinois Geol. Surv., p. 144, pl. xviii, figs. 19–23.

The youngest example of this species I have found is subcircular, and has a diameter of 0·4 mm., the brachial valve is gently convex, hinge-line and beak very obscure. Specimens of 1·0 mm. in diameter are slightly transverse, with well-defined hinge-line and less obscure beaks; the brachial valve generally exhibits one or two well-defined growth-lines. At this stage in the development of the shell the pedicle valve is closely cemented to the host, the hinge-line and beak only being raised above the level of the front and sides. However, upon reaching maturity, or approximately 2·5 mm. in diameter, a trail begins to form by the abrupt upward

deflection of the anterior margins of the pedicle valve and a thickening or piling up of the shell layers along the margins of the brachial valve. With the upward deflection of the anterior and lateral margins of the pedicle valve, a number of irregular, hollow, spine-like digitations form around the margins of the pedicle valve and continue to grow outward, closely adhering to the surface of the host. When the size of the host is small, as in the case of a small crinoid column, the digitations in following the surface appear to clasp the host, but I can scarcely attach any morphologic significance to the fact.

ETHERIDGINA INCONDITA n.sp. (Pl. XIV, Figs. 16–18.)

Shell minute, seldom attaining a diameter greater than 2·5 mm., breadth somewhat greater than length; very irregular in outline. Pedicle valve cemented to foreign objects and conforming to their surface; area of attachment confined to the visceral region; beak free and slightly raised. Anterior and lateral margins of the valve deflected upwards at maturity and forming a trail. Brachial valve flat or somewhat convex, except along the anterior margins; here a rim is formed where the edges conform to the upturned margin of the pedicle valve. Hinge-line as long as or slightly shorter than the greatest breadth of the shell; a linear cardinal area, delthyrium, and well-developed teeth are present. Spines variable in number and confined to the margins of the pedicle valve.

This interesting little species is found in the Elmdale Formation (Pennsylvanian), in the vicinity of Beaumont and Cambridge, Kansas, attached to the larger brachiopods of the fauna. It occurs less abundantly in the Kansas City Formation (Pennsylvanian), in Jackson and Grundy Counties, Missouri.

Holotype: the original of Fig. 16, from Beaumont, Kansas (author's collection).

ETHERIDGINA? SPONDYLIFORMIS White & St. John. (Pl. XIV, Fig. 15.)

1868. *Aulosteges spondyliformis* White & St. John, Trans. Chicago Acad., vol. i, pt. i, p. 118, text-fig. 2.

1915. *Strophalosia spondyliformis* ? Girty, Bulletin 544, U.S. Geol. Surv., p. 80, pl. x, fig. 8.

I know this interesting little species only from the description and figure given by the authors, and its relationship to the species here discussed is inferred wholly from a study of the description. Dr. Girty has figured and referred to this species a very obscure specimen from the Wewoka Formation (Pennsylvanian) of Oklahoma.

Hall & Clarke figure a *Strophalosia spondyliformis*; vol. viii, pt. i, pl. xvii*a*, figs. 25–6. This is a true *Strophalosia*; it is a rare species in the Kansas City formation. All specimens of the species in my collection show a misshapen and twisted pedicle beak, and, invariably, a cicatrix of attachment.

EXPLANATION OF PLATE XIV.

FIG.

1. *Etheridgina complectens* (Etheridge). × 4. View of pedicle valve, after Etheridge, 1876.
2. Id. × 4. View of pedicle valve, after Etheridge, 1878.
3. Id. × 4. View of conjoined valves, figure by Greger from Fifeshire specimen.
4. *Etheridgina radicans* (Winchell). × 2. Interiors of two pedicle valves, after Beecher.
5. Id. × 2. View of specimen with conjoined valves, after Beecher.
6. Id. × 2. View of pedicle valve, after Hall & Clarke.
7. Id. × 3. View of conjoined valves, after Hall & Clarke.
8. Id. × 3. View of pedicle valve, after Hall & Clarke.
9. *Etheridgina keokuk* (Beecher). × 2. View of conjoined valves, after Hall & Clarke.
10. Id. × 2. View of pedicle valve, after Beecher.
11. Id. × 2. View of specimen with conjoined valves, after Beecher.
12. *Etheridgina scintilla* (Beecher). × 4. View of pedicle valve, after Hall & Clarke.
13. Id. × 6. View of pedicle valve, after Hall & Clarke.
14. Id. × 3. View of specimen with conjoined valves, figure by Greger from specimen from type-locality, Louisiana, Pike County, Mo.
15. *Etheridgina? spondyliformis* White & St. John. Copy of the original figure.
16. *Etheridgina incondita* sp. nov. × 4. Holotype. View of pedicle valve, specimen from Beaumont, Kansas.
17. Id. × 4. View of pedicle valve, specimen from Cambridge, Kansas.
18. Id. × 4. View of pedicle valve, specimen from Kansas City, Mo.

On a New Ammonite Genus (*Dayiceras*) from the Lias of Charmouth.

By L. F. SPATH, M.Sc., F.G.S.

(PLATE XV.)

THE following account is based on the six specimens recorded by Dr. W. D. Lang in his paper on "The *Ibex*-zone at Charmouth, and its relation to the Zones near it"[5]. After mentioning the occurrence, in the top of the zone, of an apparently new Polymorphitid, Dr. Lang added the following footnote: "A striking form, 3 to 4 inches in diameter, with numerous, very thin costæ. Two specimens were found (not in place) in the winter, 1915–16, by Lieut. Dan Haggard, who presented them to the British Museum. The author found parts of three specimens in place in the Pyritic Marls in June, 1916. A sixth specimen, the best preserved of all, has been in the British Museum many years, and is labelled 'Said to be from Lyme Regis'."

[1] F. R. C. Reed, "The Lower Palæoz. Trilobites of the Girvan district": Mon. Palæont. Soc., 1903–6, pp. 146–7.

[2] Also ibid., pl. xix, fig. 2.

[3] H. Woodward, GEOL. MAG., 1880, pp. 97–9.

[4] L. Dollo, "La Paléontologie Ethnologique": Bull. Soc. belge de Géol. Mem., Bruxelles, Tome xxiii, 1909, pp. 406–17. See also H. H. Swinnerton, GEOL. MAG., Vol. LVI, 1919, pp. 108–9.

[5] Proc. Geol. Assoc., vol. xxviii, pt. i, 1917, p. 32. A seventh example was found by Dr. Lang in May, 1920.

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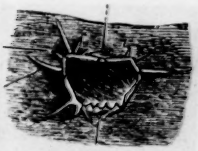
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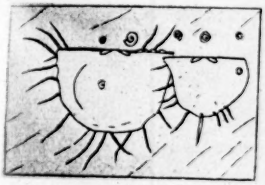
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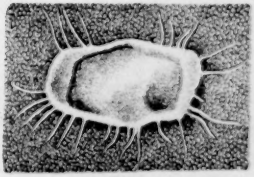
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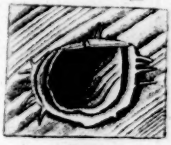
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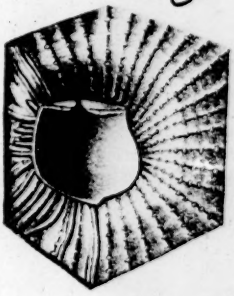
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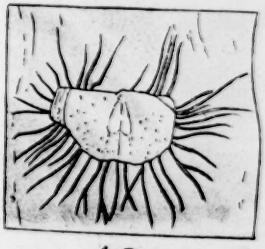
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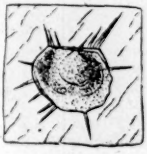
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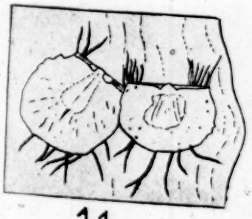
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ETHERIDGINA.

The writer is indebted to Dr. Lang for permission to describe his specimens, also for many valuable suggestions. The writer also hopes to publish in the near future a complete account of the Polymorphidæ of the *ibex*-zone at Charmouth, especially of the successive developments of *Acanthopleuroceras* announced by Dr. Lang in his paper. These will offer a better opportunity for correlating the beds which yielded the new forms described in the present paper. Five of the six specimens mentioned above are considered to belong to one species, but their description is given separately, since, owing to differences in the mode of preservation, crushing, or rolling, each specimen shows interesting peculiarities which supplement the evidence of the holotype.

The specimen selected as type is the one that had been exhibited for years in the British Museum (Natural History) as an example of an "Ammonite replaced by Iron-Pyrites" (specimen No. Z 216). It bears the label "Apparently new. Bought at Lyme Regis, and stated to have been found there. F. H. Butler". The dimensions are:—

Diameter	83 mm.
Height of the last whorl	31 %
Thickness of the last whorl	21 %
Umbilicus	45 %

At a diameter of 60 mm. these percentages are respectively: 31, 21, 44. The specimen has the (limonitized) shell attached, except on the more prominent parts, such as the crests of the ribs and the peripheral tubercles. This abrasion is probably due to a certain amount of rolling, which would account not only for the rounding of the periphery but also for the apparent duplication of some of the costæ. Apart from this, however, there appears to be a flat septum in each costa, which itself was probably hollow and very sharp, if one may judge by the other specimens. The ribs may therefore appear flat and broad, after the style of annulate Dactyliocerati, even where there was abrasion of only the crest and tubercle, and where the inner shell or septum still adheres to the rib (Fig. 2). The number of costæ is 114 to the whorl at a diameter of 83 mm. and about 116 at a diameter of 55 mm. Each begins with a striking backward bend at the umbilical slope (Fig. 4), and describes a sigmoidal curve on the lateral area, ending near the ventral margin with an elongated tubercle or thick ending. In Fig. 3 this is indicated from the evidence of the other specimens; but in the holotype the periphery is more or less worn throughout.

The whorl-section is rounded, with its greatest thickness about midway between the periphery and the umbilical suture; but, owing to the wearing down of the ornament, the sides appear to be flattened on the last whorl; and, especially near the end, the shell is poorly preserved. From evidence, however, of the inner whorl, it appears that the sides were regularly convex, and this regular rounding is

also shown in specimen C 18836. Fig. 1*b* is a restored outline-section.

The umbilical edge is somewhat abrupt and the slope is flattened where the costæ describe the peculiar bend shown in Fig. 4. The involution is very slight, which character, together with the peculiar costation, gives these forms a lytoceratid aspect. A specimen from the Crumbly Bed, shown to the writer by Dr. Lang, is in fact a (poorly preserved) *Fimbrilytoceras*.

Owing to the difficulty of removing the (limonitic) remains of the shell from the interstices between the ribs, the suture-line could not be exposed satisfactorily. Fig. 1*c* is composite, made up from portions of several suture-lines at a diameter of 65 mm., i.e. about a third of a whorl from the end of the shell. Since there are traces of the suture-line still at the end, the specimen complete with its body-chamber must have been over 120 mm. in diameter.

Specimen 3770 (Coll. W. D. Lang), from the Pyritic Marls, 16 inches below the Belemnite Stone at Westhay Water, 1¼ miles east of the mouth of the River Char, is nearly complete, though crushed, and at a diameter of 90 mm., has:—

Height of the last whorl	33 %
Umbilicus	44 %

The thickness of the shell is 22 per cent in the one place where there is no compression, so that there can be no doubt that the specimen is specifically identical with the type. The costation is just a trifle closer, however, since there are about 125 ribs on the last whorl. It may be added that, though the innermost whorls are not preserved, the peculiar costation of the species is already shown at a diameter of 15 mm.

Since traces of what probably was the last suture-line are shown at a diameter of 80 mm., the complete shell must have been considerably larger than the preserved portion. At this spot also (just before the commencement of the crushed body-chamber) parts of the shell are preserved on the periphery. The median row of tubercles was much more distinct on the shell than on the pyritic cast, and the rounded prominences composing it alternate in position with the thickened and forwardly-bent terminations of the lateral ribs. A very indistinct ridge in the shape of a Λ seems to connect the three lines of tubercles across the periphery.

Specimen 3769 (Coll. W. D. Lang), from 12 inches below the Belemnite Stone, Cliff Base, south-west of Golden Cap, consists of half a whorl of an Ammonite about 47 mm. in diameter. The specimen is partly crushed, but typical and extremely finely costate. It clearly shows the prominent median line of tubercles on the periphery, but the two lateral rows of tubercles are irregularly crushed against it in places. The specimen is not pyritized, as the others are, but preserved in the peculiar pyritic-marly matrix of its bed, and like other fragmentary fossils from this horizon suggests disturbed deposition.

Specimen 3768 (Coll. W. D. Lang), from the Crumbly Bed, exposed at low spring tides on the floor of Cann Harbour, Golden Cap, represents an impression, on a mass of pyrites, of a shell probably about 80 mm. in diameter. At a diameter of 47 mm. the height of the last whorl appears to be 30 per cent. and the umbilicus 44 per cent of the diameter. The typical close costation is shown already on the innermost whorls, and may be taken to characterize the specimen sufficiently, but the peripheral ornament is not preserved. At the diameter of 10 mm. the last half-whorl shows about thirty (?) costæ.

Specimen C 18836 (British Museum, Nat. Hist., Dan Haggard Coll.), from near Charmouth (500 yards east of the mouth of the Char River, not found in situ), is preserved in a pyritic concretion which obscures much of the shell and all the inner whorls. The specimen is uncrushed, however, except near the end, and measures about 60 mm. in diameter. Where the last whorl protrudes from the mass of pyrites, at a diameter of 45 mm., the thickness is 21 per cent of the diameter. The ornament is typical and the periphery is particularly instructive in this specimen; for it shows both the true character of the high, median tubercle, and the sharp points of the ends of the costæ; also the deceptive appearance of the periphery where the worn-down ornament produces a rounded ventral area with the flattened costæ almost touching the siphonal line. (Compare Figs. 2 and 3.)

The distinctive characters of the new form, as shown by these five specimens, then are: (1) an extremely fine and close costation and (2) a median row of tubercles along the siphonal line, accompanied by two lateral rows of elongated tubercles or rather the thickened terminations of the costæ. These five specimens are considered to belong to one species, *Dayiceras polymorphoides* nov. (genotype), the generic name being proposed (on a suggestion from Dr. Lang) to commemorate the important work of E. C. H. Day on the Lias at Charmouth.

The last specimen, No. C 18835 (British Museum, Nat. Hist., Dan Haggard Coll.), from about 500 yards east of the mouth of the Char River (not in situ), differs from the other five in having a less close costation, namely, 84 costæ on the last whorl shown, as compared with 116 in the type of *Dayiceras polymorphoides* at a similar size. It is preserved in pyrites, but crushed, and has portions of one of the high-zonal Acanthopleurocerates, characteristic of the Pyritic Marls, attached to it. Its diameter is 57 mm. The periphery unfortunately is very imperfect, and the trituberculation is indicated only near the end; whereas the first half of the outer whorl, owing to the crushing, shows a very thin venter with the ribs apparently meeting at a keel (after the manner of certain carinate *Polymorphites* or the extreme form of *Uptonia jamesoni* figured by Haug[1]). It

[1] N. Jahrb. f. Min., etc., 1887, pl. v, fig. 1*b*.

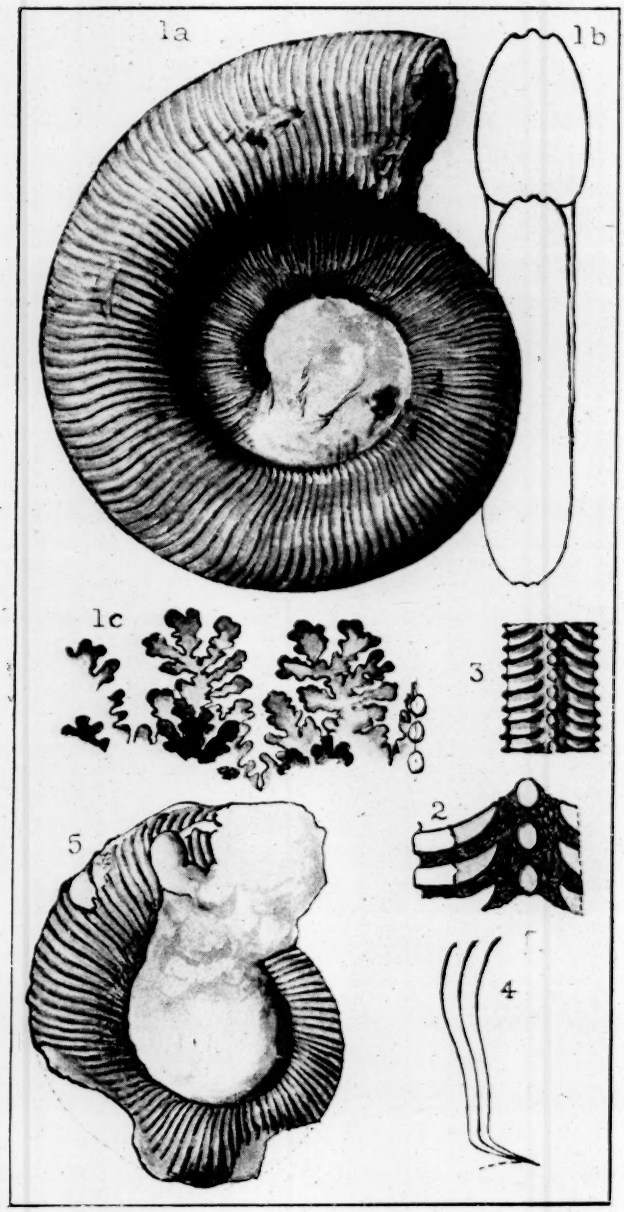
should be mentioned, however, that here the periphery has also been worn down, probably to the extent of several millimetres. It is to be regretted that the state of preservation of this ammonite does not permit of more exact comparison with the other specimens described in this paper or with the genus *Polymorphites*. The suture-line seems to be considerably simpler than that of *Dayiceras polymorphoides*, though it could not be exposed clearly enough for delineation. On the other hand, the specimen shows the very peculiar costation of *D. polymorphoides* in places (if less close), also, apparently, the typical peripheral ornament. In the circumstances it seems advisable to consider it a distinct form from *D. polymorphoides*, and the name *Dayiceras langi* [1] is here proposed.

Since the development could not be studied in any of the specimens, it may be premature to speculate on the probable evolution of the new series and its connexion with the genus *Polymorphites* and the other Polymorphidæ. But in justification of the new generic name proposed here the following observations may be offered. The adult suture-line of *Dayiceras polymorphoides* is of the complex type of certain finely-ribbed (and probably post-*jamesoni*) *Uptonia*, the exact relationship of which both to typical *Uptonia* and to *Polymorphites* has yet to be worked out.[2] The typical group of the genus *Uptonia* has its maximum development in the upper portion of the *jamesoni*-zone, and the forms have a tendency towards continuing the costation across the periphery. Without going, for the present, into the complex interrelations of the family Polymorphidæ,[3] it may be mentioned that some forms, indefinitely referred to *U. bronni* (which, however, is keeled and has a comparatively simple suture-line), may show the lateral tubercles moved considerably nearer to the siphonal line, also an indistinct notching due to the median line of slightly raised apexes of the V's along the periphery. So far as the writer is aware, however, nothing like the fine and close costation of the new forms described here has been observed in these *Uptonia*. The genus *Polymorphites*, on the other hand, is characterized by a very simple suture-line. In the typical forms of this genus (the small-sized, very variable *Polymorphus* group, and not the forms of *Gemmellaroceras*, often included here) tuberculation of the periphery also occurs occasionally, notably in *P. caprarius* Quenstedt sp., though here the costæ are bituberculate. In the lineate species of the genus *Polymorphites*, however (with merely angular periphery), there is a certain resemblance to the new forms. But on present evidence it seems inadvisable to include the new series which, at Charmouth, occurs in post-*ibex* times (yet

[1] Dedicated to Dr. W. D. Lang in recognition of his prolonged and painstaking investigations of the Liassic succession at Charmouth.

[2] The writer considers that *A. vernosæ* Zittel, probably a Toarcian form, does not belong to *Uptonia*.

[3] Confined, in the writer's opinion, to the *jamesoni* and *ibex* zones, and not including e.g. the Domerian *Boucericeras* and later *Hildoceratids*.



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NEW AMMONITE GENUS (DAYICERAS) FROM THE LIAS OF CHARMOUTH.

To face p. 543.]

in the *ibex*-zone), together with *Liparoceras*, and which attained considerable size, in the genus *Polymorphites*. It appears to be a late and independent development of the Polymorphidæ, and possibly local, since nothing like the new forms has been recorded from such well-searched localities as e.g. Wurtemberg. It may be added that though the *ellipticum* group of *Tropidoceras*, with all its variations, and possibly some *Tragophylloceras* of the *Wechsleri* group, confused with *Amphiceras*, occur in Sicily, and both *Uptonia jamesoni* and *Acanthopleuroceras valdani* are widely distributed in the Mediterranean province also, there apparently is nothing comparable to the new genus *Dagiceras*, or, indeed, to the typical post-*jamesoni* genus *Polymorphites*.

EXPLANATION OF PLATE XV.

FIGS. 1–4.—*Dagiceras polymorphoides* nov. gen. et sp. Lias (Pliensbachian, *ibex*-zone), Charmouth. Specimen No. Z 216, British Museum, Natural History.

FIG. 1*a*.—Side-view of holotype, nearly natural size.

FIG. 1*b*.—Restored outline section.

FIG. 1*c*.—Portion of suture-line, magnified.

FIG. 2.—Portion of periphery, magnified, to show limonitic outer shell (dark), inner shell or septum, also limonitic (gray), and pyritic cast (two ribs on left, clear).

FIG. 3.—Periphery restored from evidence of several specimens.

FIG. 4.—Rib-curve, with strong forward bend at umbilical slope.

FIG. 5.—*Dagiceras langi* nov. Side-view, nearly natural size. Lias (Pliensbachian, *ibex*-zone), Charmouth. Specimen No. C 18835, Dan Haggard Coll., British Museum, Natural History. No sectional view is given, since the specimen is crushed.

The Mineral Composition of the Modern Fenland Silt, with special reference to Carbonate Minerals.

By F. HARDY, M.A. (School of Agriculture, Cambridge)

I. INTRODUCTORY

IN July of 1919 the writer assisted in a soil survey of the salt marshes of the north-west shores of the Wash.

During the course of the work it became necessary to examine microscopically specimens of marine silts forming the salt marshes, with a view to elucidating the reason why the silts generally have an abnormally high carbonate content.

It was found that the carbonate minerals in the material examined were of several kinds. Amongst them dolomite ($MgCO_3$. $CaCO_3$) was definitely identified. This discovery suggested a line of work both of geological and mineralogical interest, and also of possible agricultural value, for dolomite is a carbonate which is not affected appreciably by weak acids (such as those that are said to be liberated in soils by the decay of humus), and it seemed reasonable to suppose

that the behaviour of the mineral in those soil processes involving the chemical action of a base, might be somewhat different from that of, say, calcium carbonate.

Hitherto chemical analyses of soils have included a determination of the total carbonate content (expressed as $CaCO_3$) irrespective of the mode of occurrence of carbonate. The usual method employed for carbonate estimation in soil-analysis is that described by Amos.[1] In this method the soil carbonates are decomposed by acting on a known mass of the soil with fairly concentrated hydrochloric acid, which is slowly heated to boiling point. The carbon dioxide evolved is absorbed in caustic soda solution contained in a Reiset tower, and its amount estimated by double titration with standard acid, using first phenolphthalein and then methyl orange as indicator.

The value of the method lies in the fact that it gives accurate results with soils which are suspected of being on the border-line of deficiency of calcium carbonate, and hence it furnishes the soil-chemist with data upon which to instruct farmers as to the advisability or otherwise of liming arable land.

The prolonged boiling with hydrochloric acid involved in the estimation is sufficient to decompose any carbonate which is likely to be present in soils. It does not differentiate, however, between easily decomposed carbonates, such as the various forms of calcium carbonate (calcite, aragonite, etc.) and the more stable carbonates, such as magnesite, dolomite, and minerals allied to the latter, siderite, $FeCO_3$, ankerite, $CaCO_3 . (Mg, Fe)CO_3$, mesitite, $2MgCO_3 . FeCO_3$, breunnerite, $(Mg, Fe)CO_3$, etc.

The inquiry naturally led to two distinct lines of investigation, one of a geological and mineralogical nature, and the other of chemical and agricultural bearing.

In the present paper it is intended to deal with the geological aspect of the subject. The results of the purely chemical side of the work, with its attendant agricultural applications, are set out in another place.[2]

In order to account for certain peculiarities of the Fenland silt soils, it would perhaps be advisable first to summarize what is known of the origin and method of formation of the Fenland silts. The geology of the silt lands is described by S. B. J. Skertchley[3] in a Memoir of the Geological Survey, from which the following account is taken.

II. GEOLOGICAL HISTORY OF THE FENLAND.

The geological history of the Fenland commences with the breaching of the one-time continuous escarpment of Chalk, which

[1] A. Amos, *Journ. Agric. Sci.*, vol. i, 1905, p. 322.

[2] F. Hardy, "A Preliminary Investigation into the Occurrence of different kinds of Carbonates in Soils," to be published in *Journ. Agric. Sci.*, vol. xi, part i, 1920.

[3] S. B. J. Skertchley, "The Geology of the Fenland" (Mem. Geol. Surv.), 1877.

joined the Upper Cretaceous highlands of East Yorkshire with those of Norfolk. The agents which effected this operation were the rivers of the early Fenland, combined with the usual agents of subaerial weathering. The breach was probably completed in pre-Pleistocene times, but prior to the oncoming of the Glacial period the covering of Cretaceous strata was completely removed from the area, so that the underlying Jurassic clays were exposed. During the Ice Age a thick covering of glacial deposits was spread over the whole or greater part of the area. Subsequent depression of the land-surface allowed the sea to extend inland, so that a great bay resulted. It was in this bay that the true Fen-beds were deposited. The inflowing rivers caused an accumulation of alluvium near the shores of the bay, and the sea-currents brought down material from the coasts of East Yorkshire and North Lincolnshire. Gradually the bay became filled with sediments, and in the south and south-eastern regions swamp-plants began to grow. The remains of these subsequently gave rise to the peat lands of the Fens.

The silts of the north-western parts of the Fenland are chiefly of marine origin. They are still being deposited along the coast of the Wash, where they give rise to salt-marsh. As the tidal water is checked in its flow, the silt falls to the bottom, and thus a bank is gradually formed against the shore. As soon as this bank rises to a certain height (estimated at 8·6 feet above ordnance datum), *Salicornia* begins to grow on it. The stems of this plant assist in the further development of the marsh by checking the flow of the water, and thus allowing a longer time for the silt to settle, and also by holding up much of the fine material when the tide begins to ebb. As the marsh increases in height, other plants establish themselves, and "green marsh" results. Green marsh is only covered by sea-water at the higher tides. It marks the stage when embanking becomes practicable.

The material of which the Fen silt is composed has been derived, as already mentioned, from the soft strata (mainly glacial) of the Yorkshire and North Lincolnshire coasts, which are rapidly being eroded by the sea. The glacial deposits themselves are of the Purple and Hessle boulder-clay type. They have been derived from the rocks over which the ancient North Sea glacier passed in its movement from the Scandinavian highlands to the coast of England, and they therefore perhaps include material taken from the bed of the North Sea.

III. MINERALOGICAL EXAMINATION OF A TYPICAL SAMPLE OF MODERN FENLAND SILT.

The sample examined and described below was taken from the foreshore of the north-west coast of the Wash immediately to the seaward of the village of Friskney. It yielded the following results when analysed :—

(*A*) *Mechanical Analysis.*

Coarse sand (1·00 to 0·20 mm.)	0·05
Fine sand (0·20 to 0·04 mm.)	84·80
Coarse silt (0·04 to 0·01 mm.)	1·65
Fine silt (0·01 to 0·002 mm.)	0·95
Clay (below 0·002 mm.)	1·14
Loss on ignition	3·20
Moisture	0·50
	92·29

(*B*) *Chemical Analysis.*

Insoluble residue	84·750
Total carbonate (as $CaCO_3$)	8·980
Total phosphoric oxide (P_2O_5)	0·112
Total potash (K_2O)	1·224
Total nitrogen	0·034

1. Examination of the Air-dried Silt without Preliminary Treatment.

A slide of the silt was prepared and examined under the petrographical microscope. The majority of the grains were found to be subangular quartz fragments. Their shape indicates that the grains had not been subjected to excessive rolling; they resemble typical boulder-clay quartz particles.

A few grains of felspar were also noted. Certain of these showed twin lamellæ and are probably of soda felspar.

The rest of the minerals (of density greater than 2·70) are described in the next section under the title of "heavy minerals". They constitute approximately 12 per cent of the bulk of the silt.

2. Examination of the Silt with a view to Identifying the Heavy Minerals.

In order to obtain grains of convenient size for petrographical examination, a quantity of the silt was subjected to a 75 seconds sedimentation process in pure water from the 7·5 cm. mark of a beaker in the manner of a mechanical soil-analysis.

The sand fraction thus obtained was collected and dried. The heavy minerals were then separated by the use of a mixture of bromoform and benzine of density 2·70.

An examination of slides prepared from this heavy mineral portion of the sand fraction of the silt yielded the following results:—

The chief minerals identified were blue-green hornblende (arfvedsonite), magnetite, glauconite and chlorite, aragonite (in the form of shell fragments and broken oolitic grains), dolomite, ferriferous chert, augite, and tourmaline. In this list the minerals are arranged in their approximate order of abundance.

Besides the above there occur also in lesser amount rutile, muscovite, biotite, staurolite, epidote, zircon, kyanite, apatite, and garnet.

(1) Arfvedsonite is perhaps the commonest heavy mineral present in the silt. It has undoubtedly been derived from the igneous

rocks of Scandinavia, which are especially characterized by the presence of this blue-green strongly pleochroic soda-amphibole. (2) Magnetite occurs as numerous well-rounded opaque grains. (3) The glauconitic material present closely resembles that occurring in the Lower Greensand deposits of certain districts of East Anglia.[1] The glauconitic grains vary in colour from pale green to deep brown. Possibly much of the pale-green material is composed of chlorite, which is closely related to glauconite. (4) Aragonite occurs in the silt chiefly as abundant fragments of shells. Prisms of the mineral (possibly derived from shells such as *Inoceramus* and from Echinoids) also occur. In addition, oolitic grains are common. These show the characteristic zonary structure, and give dark crosses when viewed under two nicols. Many of the oolitic grains are highly ferriferous, and the aragonite of which they were originally composed may have been altered by impregnation with iron and magnesium into some such mineral as ankerite. (5) The dolomite present occurs as typical "fresh"-looking crystals of rather large size and with well-marked rhombohedral cleavages. Dr. Harker, who examined certain of the slides, expressed the opinion that the appearance of the dolomite grains suggests a secondary and comparatively recent origin of the mineral. Possibly the mineral was deposited from sea-water, and the crystals gradually built up during the successive wettings and dryings to which the modern Fenland salt-marsh silts are subjected. (6) The mottled grey-brown grains of chert owe their high density to the presence of abundant iron oxide in them. The grains are of comparatively large size, and possess a cryptocrystalline structure. (7) Augite occurs as colourless or pale-green angular fragments, which owe their shape to the imperfect cleavage of this mineral. (8) The presence of tourmaline is noteworthy. The commonest colour exhibited by the well-rounded drop-like grains of this mineral is olive-green, although a very few pink grains were seen. The tourmaline grains resemble on the whole those which characterize the Lower Greensand strata as described by Rastall. (9) Of the less common heavy minerals, rutile is conspicuous. It occurs chiefly as rounded brownish-red grains of typically high refractive index. (10) Muscovite is fairly abundant as thin flakes of various sizes. Its presence was rendered conspicuous by illuminating the slides under examination by light of grazing incidence. (A further comment on the occurrence of muscovite in the silt is to be found in the next section.) (11) Biotite is not very abundant, but it is undoubtedly present in appreciable amount. The mineral is of exceptional occurrence in sediments generally. (12) Staurolite occurs as rounded yellowish fragments of strong pleochroism and high refractive index. (13) Epidote was seen in a few angular fragments, of which a certain number possessed a thin coating of iron oxide. (14) Zircon is rare.

[1] R. H. Rastall, "Mineral Composition of Lower Greensand Strata of East England": Geol. Mag., Vol. LVI, 1919, p. 269.

When it occurs it resembles the grains of that mineral in the Lower Greensand. (15) Kyanite is present as large blade-like fragments, several of which exhibit the characteristic re-entrant angles, giving a waist-like appearance to the grains. (16) Apatite occurs in small amount as tiny rounded, colourless, highly refractive grains. (A further note on its significance in the silt is given below.) (17) Garnet is fairly abundant as colourless, more or less angular chips of high refractive index. Such grains of garnet are characteristic of many geologically recent sands of East Anglia,[1] and also of certain of the Lower Greensand strata.

3. Note on the Composition of the Finer Fractions of the Silt.

An attempt was made to identify the minerals present in the silt and clay fraction of the sample, but it was only found possible to recognize definitely the presence of quartz as the main constituent of the material; of muscovite in abundant small flakes; of tiny angular fragments of zircon, and of much calcareous matter.

IV. The Origin and Geological Relationships of the Modern Fenland Silt.

Assuming that the sample of Fenland silt described above is fairly typical of the uniform deposit which is slowly being accumulated along the north-west border of the Wash, certain conclusions as to the relationship of the silt may be drawn from its mineralogical composition.

The general assemblage of minerals is very similar to that of certain of the geologically recent deposits of Cambridgeshire, as described by Rastall. It is almost identical with that of the finer parts of the plateau-gravels, which are most probably the residue of the boulder-clay of the North Sea glacier. Hence it may be assumed that such boulder-clay has furnished the bulk of the material of the modern Fenland silt.

The presence in the silt of calcareous oolitic grains, which have been generally somewhat altered by secondary processes, may be due to the admixture of detritus from weathered Jurassic rocks over which the Fenland rivers flow in their courses to the Wash. These conclusions are in full accord with the geological evidence which has already been summarized in Section II.

V. The Bearing of the Mineralogical Composition of the Modern Fenland Silt on certain Chemical Characteristics of the Silt.

(A) Carbonate.

The establishment of the presence of two distinct kinds of carbonates in the silt sample examined is perhaps the chief point of chemical interest in the investigation. The writer has elaborated

[1] R. H. Rastall, "The Mineral Composition of some Cambridgeshire Sands and Gravels": *Proc.* Camb. Phil. Soc., vol. xvii, 1912, p. 136, etc.

an analytical method for estimating the percentage amounts of the more easily decomposed ("calcitoid") carbonate, and of the carbonate of greater stability ("dolomitoid carbonate") in marine silt soils. Applying the method to the sample described above, it was found that of the total 8·98 per cent of carbonates in the silt, 5·75 per cent was easily decomposed by acids (i.e. soluble in N/3 acetic acid), whereas 3·23 per cent (by difference) required a stronger acid for its decomposition, and is assumed therefore to be of the nature of dolomite or allied mineral carbonate.

The details of the analytical method used in the estimation of calcitoid and dolomitoid carbonate in silt soils, and an account of the agricultural significance of the presence of these two kinds of carbonates in such soils, are given in the writer's forthcoming paper already quoted.

(B) Potash.

The chief potassium-containing mineral in the silt is muscovite, and it is noteworthy that the greater amount of this mineral appears (from the petrographical examination) to occur in the finer fraction of the material. Although orthoclase felspar was identified as a constituent of the silt, it was noted that its amount was comparatively small. The only other possible potassium-containing minerals identified were tourmaline and glauconite. The former mineral, however, is so very stable that it is of no importance as a source of potash in soils containing it, and glauconite, which when fresh may contain as much as 8 per cent of K_2O,[1] is here present chiefly in a much decomposed state and also in such comparatively small amount that it may be left out of consideration as an important source of potash in the silt.

Thus the chief source of potash for the use of crops grown on Fenland silt similar to that described is muscovite.

According to the chemical analysis, the total percentage of K_2O in the silt examined in 1·224. This corresponds to about 10 per cent of muscovite (assuming the absence of other potash-minerals). It is relatively high as compared with the K_2O content of typical soils, which usually lies between 0·1 and 1·0 per cent. Nevertheless, the successful growth of crops (especially potatoes) in the cultivated regions of the reclaimed silt Fenlands frequently necessitates the liberal use of potassic fertilizers. This fact suggests that the potash supply of the Fenland silt soils is only relatively slowly available, so that it may fail to satisfy the full needs of certain crops which require an abundance of this plant food. It may be explained by the resistance to weathering which is a known characteristic of muscovite.

(C) Phosphate.

The only phosphatic mineral found in the silt was apatite. Chemical analysis showed that the total phosphate (P_2O_5) present

[1] Clarke, "Data of Geochemistry": *Bulletin* 616, U.S. Geol. Surv., 1916, p. 516.

in the silt sample is 0·112 per cent, which corresponds to about 0·28 per cent of apatite. Frequently in soils (especially in peat and other soils rich in humus), phosphorus probably also occurs as organic phosphorus compounds. In the case of the silt under consideration, the possibility of the presence of organic phosphorus is negligible, since the silt contains only 0·034 per cent of nitrogen (corresponding to about 0·48 per cent of humus). Hence we may safely assume that the only phosphorus compound present in the silt is the mineral apatite. The percentage of phosphate (0·112 per cent P_2O_5) is of average amount for a soil: the range for typical soils being between 0·06 and 0·20 per cent P_2O_5.

(D) Other Mineral Plant-foods.

The silt sample contained an abundance of magnesium-containing minerals, and also of minerals containing iron, sodium, and calcium, so that there is no danger of a deficiency of these essential elements of plant growth should the land subsequently be brought into cultivation.

The above results furnish an example of the importance of a mineralogical examination of a soil-type with a view to interpreting the figures obtained by a chemical analysis carried out along conventional lines. In the opinion of the writer too little attention is paid to the possible aid which mineralogy may afford the soil-chemist in his efforts to appreciate the special agricultural treatment frequently needed by certain soil-types under an intensive system of cultivation.

In conclusion, the writer wishes to express his indebtedness to R. H. Rastall, M.A., for his invaluable assistance and sympathy during the progress of the work outlined above. Also to E. J. Roberts, of the Cambridge School of Agriculture, for permission to use the results of the analysis of the sample chosen for examination.

SUMMARY.

1. A sample of modern Fenland silt containing 8·98 per cent of carbonate was found on mineralogical examination to include dolomite as well as aragonite in its mineral assemblage.

2. The dolomite is present in fresh angular crystal grains which suggest a secondary and recent origin of the mineral. It has possibly been deposited from sea-water which periodically covers the foreshore of the Fenland border of the Wash.

3. The general mineral composition of the silt resembles closely that of certain geologically recent deposits of Cambridgeshire, and points to the boulder-clay left by the North Sea glacier as the chief source of the material of which the silt is composed. The silt has mainly been deposited by sea-currents which carry southwards the eroded glacial deposits of the South Yorkshire and North Lincolnshire coasts.

4. An attempt is made to interpret the results of a chemical analysis of the silt in the light of its mineralogical composition, chiefly with regard to carbonate, potash, and phosphate. Muscovite, is found to be the main source of potash, and apatite of phosphate in the silt.

A Theory of the Marginal Drift.

By W. B. Wright

IT is a fact well known to geologists that the drifts laid down in the peripheral portions of the area affected by the Quaternary Glaciation differ markedly from those developed nearer in to the glacial centres. Beyond, perhaps, a vague suggestion that this may have been due to different climatic conditions during the successive stages of the retreat, no adequate or even partial explanation of the phenomenon has ever been brought forward. Pursuing a line of thought suggested by Dr. Matti Sauramo, in his paper on the glacial retreat in Southern Finland,[1] it now seems possible to offer an explanation based merely on the simple assumption of a greater degree of cold during the maximum of glaciation than obtained during the later stages of the retreat.

The peculiarities of the marginal drift which call for explanation may be briefly summarized as follows :—

(1) The absence along the outer edge of the drift-sheet of any terminal moraines, such as were developed during periods of halt or readvance in the later stages of the retreat.

(2) The attenuated character of the drift and the extreme indefiniteness of its margin, the so-called "feather-edge".

(3) The almost complete absence of eskers and outwash fans, such as might indicate a normal amount of melting during the initial stages of retreat.

(4) The apparent absence of any of the phenomena of marginal drainage.

(5) The absence of drumlins or more generally of topographic expression of any kind.

(6) The presence of a covering of loess.

These characteristics are, of course, mainly of a negative character, but they are none the less remarkable. The first five might well be summed up in one word—feebleness.

The Fundamental Observation.—The conclusion of Dr. Sauramo, from which it is now proposed to build up an explanation of this feebleness of the outer drifts, is based on a study of the later phases of the retreat. These were in general characterized by active motion and rapid decay, the essential requirements for the production of end-moraines, eskers, and outwash fans, but a return at intervals

[1] Matti Sauramo, "Geochronologische Studien über die Spätglaziale Zeit in Südfinnland": Bulletin de la Commission Géologique de Finlande, No. 50, 1918.

to severer climatic conditions gives us some insight into the effects of reduction of temperature on the activities of the ice-sheet.

In virtue of its discharge into the waters of the late-glacial sea the outwash from the ice-margin, during its retreat across Finland, has produced in that country a series of clays with well marked seasonal laminæ, which give an effective measure of the rate of ablation. During the several halt-stages, the most marked of which are those corresponding to the inner and outer wreaths of the Salpausselkä Moraine, ablation as recorded by these laminæ was reduced to a minimum. It is a fairly safe deduction that these halts in the retreat were the result of a lowering of temperature, probably of mean annual temperature, but most certainly of summer temperature, since the coarse summer zone is almost wanting in the laminæ. Further, on mapping out the successive portions of the ice-margin and plotting the rate of retreat against the corresponding year, Dr. Sauramo discovered that, in almost every case, a halt was followed by an acceleration in the rate of retreat, lasting for a period of some fifteen years or so, after which there was a gradual reversion to the normal rate. From this result, combined with the fact that the laminated clays corresponding to these years of rapid retreat show no evidence of abnormally great ablation, he draws the conclusion that during the preceding halt-stage the margin of the ice-sheet had become thinner, and consequently wasted away more rapidly when the normal ablation was restored.

Now, wasting without any equivalent ablation is capable of one interpretation only. It clearly must be due to evaporation from the surface of the ice-sheet, that is, passage from the solid to the gaseous state either directly or with so little development of water that the latter merely moistens the surface snow and forms a zone of slush, but never gathers into runnels and streams. The zone of slush, according to the observations of Nansen, is not, even in the case of Greenland ice, which is undergoing ablation, of any great width. The conclusion, therefore, to be drawn from Dr. Sauramo's observation is that direct evaporation from the ice may, under sufficiently low temperature conditions, become an important factor in glacial control.

The Glacial Anticyclone.—It is now widely recognized that an ice-sheet, once it attains sufficient magnitude, establishes its own permanent meteorological conditions and wind system, the so-called "glacial anticyclone". It is nourished, not by snowfall as we know it, but by frost-snow or ice-crystals precipitated from the descending air of the anticyclone when it comes into proximity with and is chilled by the surface of the ice. The central portions of the anticyclone draw upon higher, colder, and drier regions of the atmosphere than the peripheral. The peripheral portions of the ice-sheet are therefore better nourished than the central, more especially if they adjoin an ocean. This is probably the explanation of the westward shifting of the centres of glaciation in the British Isles emphasized

by Mr. Lamplugh, and the corresponding eastward shifting in North America. Mr. Lamplugh expressed the idea by saying:[1] "As the plateaus of ice rose higher in the path of the moisture-laden air-currents they must have gained increased effectiveness as condensers, thereby not only augmenting the snowfall in one quarter, but also diminishing the precipitation in the region to leeward." It might be more in conformity with modern ideas of the meteorology of ice-sheets to say that they drew down upon their surface the bulk of the moist air of the upper current which was passing across the ice margin towards the interior in virtue of the anticyclone circulation.

The Limiting Factors.—It is clear from what has been said above that, as an ice-sheet expands, its central area becomes starved, active precipitation being confined to the peripheral areas. Even in these latter, however, area for area there is less nourishment, as each sector of the front has a progressively narrower sector of the extra-glacial region to draw upon for its moisture. This is the first factor tending to set a limit to the growth of an ice-sheet, and it is to be noted that it is independent of any amelioration of climate.

The second and perhaps the more important factor is the increased wastage consequent on expansion. This is, of course, obvious if the ice-sheet is thrusting forward into the zone of ablation, but even if this zone is never reached there must ultimately come a limit. With increase in size and power there is drawn down the central pipe of the anticyclone a continually greater proportion of dry air from the upper regions of the atmosphere, and this spreading radially over the surface of the ice causes ever-increasing evaporation. Towards the periphery it no doubt partly mixes with, but also tends on account of its great weight to wedge in below, the moisture-bearing air descending in the zone of nourishment. The evaporation effect demonstrated by Sauramo to be a working factor in the colder stages of the Finnish retreat may thus become a really powerful agent of control during the rigour of the glacial maximum.

Effect of Accumulated Gradient and the Radial Snow-drift.—Thus, with failing nourishment and increasing wastage by evaporation, an ice-sheet may reach a limit of growth without ever extending into the zone of ablation. It is now losing by evaporation as much as it gains by precipitation. Its powers of expansion, however, do not stop here, for it has accumulated a gradient, and must consequently extend its frontiers until the gradient becomes so low as to be inoperative. In doing so it still further decreases its nourishment and increases its evaporation, so that the latter becomes dominant. It is already wasting from above downwards where it reaches its maximum extent, and this wasting continues until the front is again withdrawn to the line of balance, where precipitation and evaporation are equal. Here it awaits an amelioration of climate before ablation can set in and further withdrawal take place.

[1] Pres. Address to Section C, British Association, York, 1906, p. 14.

The belt thus gently invaded with progressively weaker motion and as gently exposed without ablation by the slow downward wasting of the dead ice is the older and featureless marginal drift. The line of balance to which the ice retreated in the case of the European Ice-sheet is somewhere in the neighbourhood of the "Young End-moraine", perhaps a little to the south of it. The exact line was probably the northern limit of the loess, which, except in a few places, does not seem to reach right up to the moraine. It seems natural to suppose that the loess which covers the marginal drift was a product of the dry climate of the maximum of cold, and ceased as soon as there occurred a rise in temperature of sufficient magnitude to introduce the factors of ablation and more copious precipitation.

The principle of accumulated or residual gradient invoked to explain the advance beyond the line of balance requires further comment, because it is not clear that the ice-motion would not in the main have discharged the gradient concurrently with the establishment of the balance. Two considerations bearing upon this point are worthy of note. In the first place ice-motion must clearly be greatly slowed down as a result of extreme cold, for it depends entirely on the phenomenon of regelation, which becomes increasingly difficult with lowering of temperature. Though the exact references have escaped his memory, the writer believes that Shackleton and Scott have both commented on this checking of glacial movement by cold as being a fact within their experience. This conception, however, when closely examined, though it makes the probability of a residual gradient greater, does not settle the question. There is, however, another means of expansion, which probably becomes of great relative importance under conditions of extreme cold. This is the snow-drift on the surface of the ice-sheet caused by the radial winds. Peary considers that in the north of Greenland this is the controlling factor in distribution. Provided the ice-margin does not extend into the zone of ablation, it is clear that it may be considerably advanced by this method even after the establishment of the balance. What is not clear is that this mode of expansion acting alone would result in sufficient ice-motion at the sole of the sheet to produce even the feebly developed marginal drifts. A combination of both agencies of advance would meet the facts admirably, and account not only for the gradual attenuation of the drift at the feather-edge, but also for such "extra-glacial" phenomena as the "trail" of Southern England.

Absence of "Marginal Drift" in the neighbourhood of the Atlantic.—It is a noteworthy fact that the belts of marginal, featureless, and loess-covered drift in Europe and America do not extend to the shores of the Atlantic, but in these areas the strongly featured loess-free drift stretches south to the line of maximum glaciation. This result is deducible from the idea that the marginal drift is the product of an advance due to residual gradient and wind-drift after the establishment

of a state of balance between precipitation and evaporation. In districts where there was a copious supply of moisture from the adjoining ocean, this balance was probably deferred to a very late stage or perhaps never reached at all. If the amelioration of climate which brought about the active motion and effective ablation of the later stages of the retreat supervened before this state of balance was reached, or even before the line of maximum extension was abandoned, then there could be no marginal featureless drift and no feather-edge in such a district. If there was ever any dead ice stage in these portions of the periphery, it did not outlast the maximum.

Summary.—Reviewing the argument once more so as to bring out its salient characters, we find that it may be briefly stated as follows. The investigation of Sauramo has established the efficiency of direct evaporation as an agent of glacial control during a cold spell. It is reasonable to suppose that during the much greater rigour of the maximum it was still more effective. Moreover, owing to the anti-cyclonic circulation the growth of the ice-sheets tended to reduce their nourishment and increase the depletion by evaporation. A balance may thus have been established between nourishment and depletion without the glacier front reaching the zone of ablation. When such a balance was established, however, motion continued owing to the already established gradient. In virtue of this residual motion, combined with the radial snow-drift, the ice-margin was advanced to its limit and subsequently withdrawn therefrom as a result of the still further increased evaporation, until it once more took up a position at the line of balance. This line in Europe is probably the northern limit of the loess, a short distance south of the "Young End-moraine". Here the ice lingered until an amelioration of climate gradually introduced marginal ablation as a new factor. This change was accompanied by greater precipitation, an inevitable result of increased evaporation, due to the rise of temperature, in the extra-glacial region. The effects were slight at first, and the beginning of the withdrawal unmarked by any recognizable moraine. After a little, however, a new gradient was established, and the ablation becoming effective, moraine formation was initiated. The first of the moraines produced by this combination of active motion and rapid decay was that known as the Young End-moraine, and from this in to the centre a progressively greater development of moraines, eskers, and outwash gravels characterized the retreat.

REVIEWS.

AN INTRODUCTION TO PALÆONTOLOGY. By A. MORLEY DAVIES, D.Sc. pp. xi, 414. London: Murby & Co. 1920. 12*s.* 6*d.* net.

THE task of writing a small textbook on the palæontology of both animals and plants, suitable for students who have had no biological training, is one of great difficulty; but much may be expected when such a task is undertaken by an experienced teacher who, as shown by his work on the *Geography of the British Isles*, is also a lucid writer.

Instead of the more usual method of describing first the zoological characters of each group, the author begins with an account of the hard parts of some typical fossil forms, and then refers to the characteristics of the soft parts as seen in living representatives; but whether this, without illustrations, will give students a satisfactory idea of the zoological characters of the group seems doubtful. The order in which the various groups are taken is: Brachiopoda, Lamellibranchia, Gasteropoda, Cephalopoda, Trilobita and other Arthropoda, Vertebrata, Echinodermata, Graptolites, Corals, Porifera, Protozoa, Bryozoa (Polyzoa), Annelida, Plants. No reason is given for this order, and it would have been easier for the non-biological student to understand the relationship of the groups if a table of classification had been given at the beginning of the book. Similarly the use of the same kind of type for the names of groups of different value—Phyla, Classes, Orders, Genera, etc.—does not make for clearness. Very unequal treatment is accorded to different groups; thus 68 pages are devoted to the Class Cephalopoda, but the great Phylum Arthropoda (other than Trilobites) is disposed of in 4 pages; the Vertebrata receive 18 pages, and Plants 13 pages. The account of the Cephalopoda seems to be more detailed than is suitable for elementary students, and would have been easier to follow if it had been divided into three sections dealing with the Nautiloidea, the Ammonoidea, and the Dibranchiata respectively.

While some parts of the book have the style of a lecture, others, notwithstanding the author's prefatory remark, approach closely to the form of a descriptive catalogue. The author is certainly not sparing in the use of technical terms, and in some places gives the impression of trying to introduce as many as possible; this will certainly not prove an attraction to non-biological students. The two chapters on "Rules of Nomenclature" and "Divisions of Geological Time", although valuable for advanced students, seem out of place in an elementary work, and we think the space might have been put to better use by giving a more adequate account of some of the groups of fossils which are dealt with too briefly.

The original illustrations are satisfactory, but the figures copied from other authors have not in all cases been well chosen; for instance, in the echinoids the figures generally omit or show

incorrectly the structure of the ambulacra—a feature of primary importance, and often not clearly seen in specimens.

We have considered this work from the point of view of the student of palæontology rather than from that of the specialist, and have drawn attention to some features in the hope that the author may have the opportunity of increasing the utility of his work. We regret that the author should have been contented with the statement "Valuable as a preliminary training in general Biology is to the student of Palæontology . . .", and we doubt if any petrologist would have made a similar remark implying that a preliminary training in Physics, Chemistry, and Mineralogy is not essential for the study of Petrology.

Pumpelly's Excavations at Anau, Turkestan, and the Origin of Domesticated Animals.

THE important archæological results of Professor Raphael Pumpelly's expedition to the Kurgans (continuously inhabited sites, now like Tumuli), of Anau in 1903–4 were made public by him in his "Interdependent Evolution of Oases and Civilizations", published in the *Bulletin* of the Geological Society of America (xvii, 1906, 637–70). The details are now made known in his "Explorations in Turkestan, Expedition of 1904. Prehistoric Civilizations of Anau" (Carnegie Institution), which contains Dr. Duerst's exhaustive report on the vertebrate remains. As to the archæology it will be enough here to roughly tabulate the results as :—

	Evidence.	*Date.*	*Proof.*
Anau V.		4th century A.D.	Sassanian coins.
Gap (strata denuded and lost).			
Anau IV.	4 feet.	Iron age (*c.* 1000–1300 B.C.)	Iron sickles. Wheel-made pottery.
Gap of 8 feet of strata apparently unoccupied.			
Anau III.	64 feet.	Copper age (*c.* 2000–)	29 copper objects; flint knives, saws and scrapers, clay figures of Ishtar, bird-headed lion seal, wheel-made pottery.
Gap (strata denuded and lost).			
Anau II	15 feet.	Early copper age (*c.* 3500–)	Flint sickles; 4 copper objects, sling stones, flint knives, hand-made pottery.
Anau I.	45 feet.	Stone age (Neolithic) (*c.* 5000–10000).	Domestic animals; only wild animal bones at base.

The special interest to readers of the Geological Magazine will naturally lie in Dr. Duerst's report, and as this is elaborate one may best secure his general results by paraphrasing Professor Pumpelly's sketch in his "Reminiscences" (New York, 1918). There were 3,500 bones, of which one-third were skulls, jaws, and teeth. Excepting human skeletons, the lower 5 feet contained bones only of wild animals. The next 40 feet contain the record of the progress of domestication on this site *successively* of ox, pig, and sheep—and

probably horse—as shown by the increasing porosity of the bones under the changed conditions of life, and by the diminutive size of the animals. First, out of *Bos namadicus* there was developed a large bovid with long horns (the same as found in ancient Egypt). At the end of Anau I there appeared a short-horned breed, which may have been produced from the long-horned ox or may be a new form brought in by the newcomers of Anau II. Domesticated pig begins to be found about 12 feet from the base. The wild *Ovis vignei* is in the lowest strata, but 28 feet above this animal had become domesticated, somewhat smaller in body, with smaller horns. This last persisted till the end of Anau I, but during the time a smaller variety was being evolved, until there was established a breed identical with *Ovis palustris*, the "turbary sheep" of neolithic Europe. The horse abounds in Anau I, and Duerst thinks it was domesticated; at any rate, it was descended from the wild *Equus przevalskii*, and appears to be the ancestor of the thin-limbed Arabian stock. Dog does not appear till late in Anau II (but its not being found is no proof of absence).

Of human remains two adults and seven young skulls were found. These are all dolichocephalic, not mongoloid, and seem to point to Mediterranean connexions.

That agriculture was known is shown by the siliceous skeletons of the chaff of a primitive variety of wheat and of two-rowed barley and chopped straw, all of which were obtained from fragments of pottery from the very lowest layers by Professor Schellenberg.

The importance of all these statements cannot be overestimated, but we can do no more here than refer the reader to the reports themselves for the details, and to Professor Myres's *Dawn of History* for their bearing on the early history of Man.

REPORTS AND PROCEEDINGS.

Mineralogical Society.

Anniversary Meeting, *November* 9.—Sir William P. Beale, Bart., K.C., President, in the chair.

Dr. E. S. Simpson: "A Graphic Method for the Comparison of Minerals with Four Variable Components forming Two Isomorphous Pairs." In the spinel-chromite series the two pairs are MgO, FeO and Al_2O_3, Cr_2O_3, and the general formula is (Mg, Fe)O.(Al, Cr)$_2$O$_3$. The relative molecular preponderances of the components of each pair stated as a percentage of the maximum are given by the formulæ: $x = 100\ (m-f)/(m+f)$ and $y = 100\ (a-c)/(a+c)$, where m, f, a, c represent the number of molecules of MgO, FeO, Al_2O_3, Cr_2O_3 respectively. The values of x and y, calculated from a number of published analyses, and from new analyses of ceylonite from Camban, Western Australia, are plotted on rectangular co-ordinates. The four corners of the main square are occupied by the pure

compounds $MgO . Al_2O_3$ (spinel), $FeO . Al_2O_3$ (hercynite), $FeO . Cr_2O_3$ (chromite), and $MgO . Cr_2O_3$ (here named picrochromite). Sub-species and varieties of intermediate composition are divided off in symmetrical areas within the square.

L. J. Spencer: "Fibrolite (= Sillimanite) as a Gem-stone, from Burma and Ceylon." Water-worn, prismatic crystals from the ruby mines in Upper Burma measure up to 1½ cm. in length, and are clear and transparent, with a pale sapphire-blue colour and marked pleochroism. A fine, faceted gem cut from this material is shown in the British Museum collection of minerals. Determinations were given of the optical constants; the birefringence shows a wide range, $\gamma-a$ being seventeen times $\beta-a$. On a somewhat similar, but etched, crystal from Ceylon the axial ratios were determined. Other crystals from Ceylon are pale greyish-green with a marked chatoyancy.

Dr. J. W. Evans: "The Origin of the Alkali Rocks." The alkali-igneous rocks form an exceptional series varying in composition from acid to basic, characterized by a high percentage of alkalies, especially soda, and a deficiency in alumina and the oxides of the divalent elements. They appear to occur mainly in areas where the earth's crust has, as the result of ancient folding or the accumulation of granitic rocks, consolidated to a considerable depth, and where the temperature gradient is abnormally low. Such are as are rarely subject to new folding, but are frequently faulted, and with these faults the alkali rocks appear to have a genetic relation. In such areas crystallization must proceed in the sub-crystal magmas, which are believed to be basic in composition under exceptional pressure, with the result that minerals with low specific volumes, having regard to the materials of which they are composed, will preferentially crystallize out. Garnet, zoisite, fibrolite, and kyanite are examples, the materials of which crystallize out under less pressure with greater specific volumes. As these minerals are mainly silicates of aluminium and the divalent elements, the uncrystallized residue will be poor in these constituents and rich in the alkalies, especially soda, which was present in the original magma in greater proportion than the potash. It will also contain the volatile fluxes in large amount. As a result of the faulting of the crust, this residue may be pressed out, find its way upwards, and give rise by further differentiation to the alkali rocks.

A. F. Hallimond: "Monticellite, from a Mixer Slag." The crystals, which are essentially monticellite containing about 20 per cent of olivine in solid solution, have the following physical characters: orthorhombic, $a : b : c = 0{\cdot}4382 : 1 : 0{\cdot}5779$; forms 010, 110, 021; refractive indices, 1·663, 1·674, 1·680; $2V$ 73¼°; specific gravity, 3·20.

Dr. H. H. Thomas and A. F. Hallimond: "A Refractometer for the Determination of Liquid Mixtures." A telescope and collimator with Websky signal are fixed in alignment; between them is inserted

a parallel-sided trough containing the liquid to be determined, in which is immersed a right-angled prism of known index near that of the liquid. Two images of the signal are formed, and the angular distance between them is read on the eye-piece scale: this reading is proportional to the difference of index between the liquid and the prism. The scale division has the same value, whatever the index of the prism used.

Edinburgh Geological Society.

October 20, 1920.—Mr. E. B. Bailey, M.C., B.A., F.G.S., F.R.S.E., President, in the Chair.

"Notes on the Structure, Character, and Relationship of the Lower Carboniferous Limestones of St. Monans, Fife." By David Tait and James Wright.

In this communication the authors gave a description, with diagrams, of the lower members of the Carboniferous Limestone Series which are exposed on the shore front in, and to the east, of St. Monans. Additional fossil lists from certain horizons were also given. Some of the points brought forward have not hitherto been published. Evidence was adduced to show that the "white" limestone of St. Monans undergoes a remarkable change from a coralliferous limestone at high-water mark at Coal Farm to a limestone of quite normal character at St. Monans Burn. Attention was also drawn to the difference in the cover of this limestone, and the change it undergoes towards low-water mark at Coal Farm. The "pseudo-brecciated" limestone of St. Monans probably owes much of its brecciated character to faulting. Besides the Coal Farm exposure, this bed also appears in its proper position on the west side of the syncline at St. Monans Burn. In all the positions examined, where it is undisturbed it may be described as a limestone of normal type; where it has been subjected to faulting, as at Coal Farm and at places on the western limb, it shows the "pseudo-brecciated" structure of the high-water exposure of the Coal Farm section. The overlying shales at such places are much disturbed and slickensided.

The higher limestones in the sequence retain their characters on both sides of the fold, but the intervening strata on the west are on the whole thicker than those on the east.

Description was also given of a remarkable limestone below the "white" limestone of Coal Farm. At high water this bed is normal and only 6 inches thick. Seawards it passes under a coralliferous layer, which gradually attains a thickness of 2 ft. 9 in., and from this point tapers away altogether. For a distance of 4 yards there is no limestone. It begins again as a thin coral bed of the same nature, thickens out to 18 inches, then dies away near low-water mark.

Attention was drawn to the nodular and other characters of these limestones and the evidence they afford of the peculiar conditions under which they were deposited.

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